Forestry Research West

Forest Service
U.S. Department of Agriculture

August 1980

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A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

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Cover

Since 1966, researchers at the Intermountain Station have been studying the effects of prescribed fires on forest resources. These scientists weighed water cans before and after a fire. Differences in weight helped them calculate the energy released by the intense prescribed burn. Read more about it on page 14

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended. If they are not handled or applied properly, pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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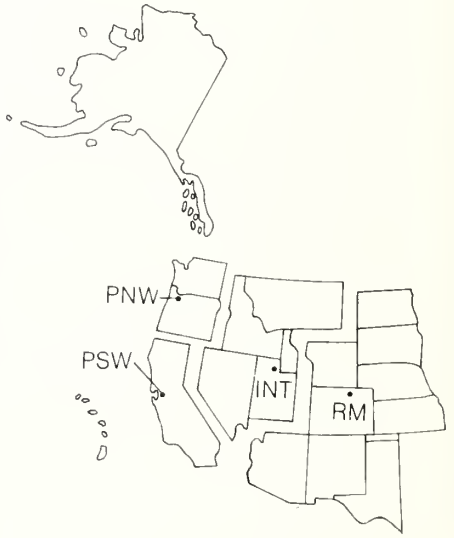


New lessons from old tussock moth outbreaks

by Dorothy Bergstrom
Pacific Northwest Station

When the Douglas-fir tussock moth—the most destructive defoliator of western forests—suddenly multiplies, and millions of tiny larvae chew their way through the foliage of Douglas-fir, white fir, and grand fir, the damage is often spectacular. It commands the immediate attention of forest managers. Finding ways to help managers control tussock moth outbreaks has claimed most of the research attention in the past. In recent years, however, considerable research has been done in an effort to learn more about the causes and effects of outbreaks and find ways to prevent them.

One important area of research deals with the long-term effects of defoliation on the growth of forests. To find out how much growth is lost and how quickly trees recover after defoliation, scientists have returned to the scene of old outbreaks. And they have found some surprises. Over the long term, stand growth is not as severely repressed as has been assumed, and growth of individual trees is often enhanced, according to Insect Ecologist Boyd Wickman of the Pacific Northwest Station's Forestry Sciences Laboratory in Corvallis, Oregon. "Our data suggest that in severe outbreaks the net result of defoliation is increased nutrient cycling and thinning of stands," he says, "We don't know yet what triggers insect populations to multiply and take on this mammoth task, but we now have a much better picture of the long-term effects of their activity."

The need for information from past outbreaks was increased when the Douglas-fir Tussock Moth Research and Development Program was established by the U.S. Department of Agriculture in 1974. One of the program's objectives was to organize information about the insect into computer models to help forest managers assess outbreaks and make decisions about the future of affected stands. When Research Forester Albert Stage of the Intermountain Station began constructing a model to predict the long-term results of outbreaks on entire stands, he found there was not enough data on stand growth. Simulations based on the performance of mechanically thinned stands were used, but do not realistically describe a severely defoliated stand at the end of a rotation.

A patch of white fir mortality (background) and scattered mortality following a severe outbreak in the Modoc National Forest.

To help gather the needed data, Wickman re-measured trees in two California stands where plots had been established following outbreaks many years ago to study the effects of defoliation. Both outbreaks were in mixed conifer stands of predominantly white fir. One had occurred in the Inyo National Forest in 1936-37, the other in the Modoc National Forest in 1964-65. While the same kinds of data had not been gathered from the two outbreaks, and neither area alone could tell a complete story, together they documented similar growth patterns following outbreaks. A more recent severe outbreak in grand fir and Douglas-fir which occurred in 1972-74 in the Blue Mountains of Oregon and Washington (Umatilla and Wallowa-Whitman National Forests) was used to study the short-term effects of defoliation.

From data on tree mortality, top kill, and stand development following outbreaks he has studied, Wickman has concluded that there is a consistent relationship between the degree of defoliation and the amount of damage for the three host species.

Mortality

The data on mortality indicate that 90 percent of the trees that die have been defoliated 90 percent or more. Trees defoliated 50-75 percent rarely die from defoliation, but some are attacked by bark beetles. Indirect mortality from bark beetles usually occurs within three years. Over half the total mortality occurs in patches which make up a relatively small portion—usually 10 to 14 percent—of an outbreak area. For example, measurements made 5 years after the outbreak in the Modoc National Forest indicated that concentrated tree mortality occurred primarily on 37 of the 450 acres of the outbreak. The remaining area had only scattered mortality. Mortality in the Blue Mountains outbreak was also concentrated in patches, amounting to about 14 percent of the outbreak area.

Top-killed white fir 10 years after an outbreak in the Modoc National Forest.

Top kill

Top kill is most common in trees defoliated more than 50 percent. The amount of top kill cannot be determined for sure until bud burst the year after defoliation but can be estimated earlier. In pole size or larger trees, die-back of one half or more of the crown is the equivalent of mortality, since trees with this much crown damage will probably also have scattered dead branches and be susceptible to bark beetle infestation and damage from heart rot.

In the Blue Mountains outbreak, top-kill damage was examined continuously during the course of the outbreak. The incidence of top kill in heavily defoliated stands was 35 percent; in moderately defoliated, 12 percent; and in lightly defoliated, 5 percent.

Tree growth following outbreaks

Both radial and height growth of trees is sharply reduced during and immediately following an outbreak. Growth reduction is proportional to the amount of defoliation and most pronounced in trees defoliated 50 percent or more. But recovery thereafter is often dramatic. Growth usually returns to pre-outbreak levels within 5 years, and after only 10 years may surpass pre-outbreak growth rates.

The remarkable recovery of individual trees is illustrated by data from the older outbreaks. During the 36 years following the Inyo outbreak, defoliated fir grew significantly faster than both nondefoliated fir growing nearby and non-host pine within the outbreak area. Even the non-host pine had a spurt of enhanced growth for 20 years.

Enhanced growth appears to be the result of increased nutrient cycling, brought about by defoliation, and the thinning effect of tree mortality. The fallen needles and insect frass (a mixture of excrement and partly digested needles) which result from an outbreak have been estimated to increase nitrogen and other nutrients to nearly 10 times the amount returned with normal litterfall. As the more severely defoliated trees die, the remaining trees benefit from increased nutrients, moisture, and sunlight.

Tussock moth outbreaks may also enhance forest regeneration. Ten years after the Modoc outbreak there were as many seedlings less than 10 years of age as there had been before the outbreak and more advanced reproduction than before the outbreak.

Stands which invite outbreaks

Studies done under the Douglas-fir Tussock Moth Program laid the groundwork for describing stands that are likely to suffer tussock moth outbreaks, and Wickman's studies of older outbreaks, both before and since the program, have provided additional clues. Most outbreaks have occurred on drier sites, such as ridge tops and south or east slopes, and in overstocked second-growth fir growing on ponderosa pine sites east of the Cascades.

The results of several ecological studies have led Wickman and other researchers to suspect that the replacement of pine with fir is the result of harvesting practices, livestock grazing, and the exclusion of fire for the past 75 years. These practices may have encouraged successional changes that have altered east side ecosystems from those that evolved naturally. "We know that the species composition of many east side forests is not the same as it was at the turn of the Century," Wickman says. "These changes have affected associated insect communities, including the tussock moth and its natural enemies, and may have set the stage for recent tussock moth outbreaks."

After 25 years of work with forest pests, Wickman shares the view of many entomologists and foresters that all components of forest ecosystems have evolved over thousands of years and are interrelated. "Bark beetles," he says, "are now generally recognized as a significant factor in the succession of pine forests." He suggests that insect defoliators play similar roles in some cases and that the tussock moth may be one of a multitude of organisms that react to changes in forest conditions. "One result of outbreaks is to restore ecosystem balance," he says. "However, when populations increase rapidly over a wide geographic area, stands on all sites, including some thrifty managed stands, have a higher probability of being defoliated. In such cases the more valuable stands will probably receive highest priority for both preventive and protective management."

Research so far indicates that trees usually grow faster following outbreaks, but how long this growth continues, what its effects are on total stand volume at the end of a rotation, and how growth compares with timber lost to defoliation are questions that can be answered only by long-term studies. Wickman plans to gather additional data from past outbreaks in California, Oregon, and Washington. Related studies by other scientists will include the use of prescribed burning to alter stand conditions, the role of birds and arthropods in insect predation, and the effects of forest management on the natural enemies of the tussock moth.

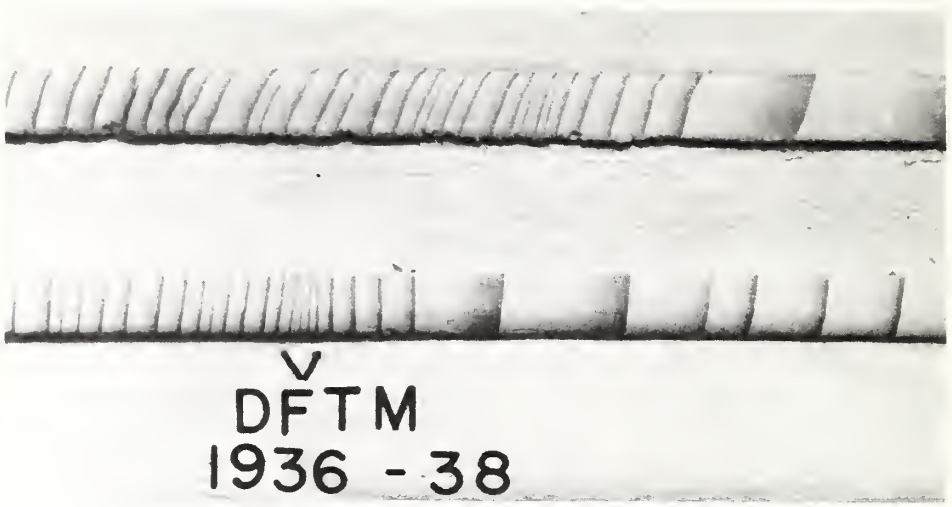
"It will take years to answer the many intriguing and important questions about the effects of defoliation on forest ecosystems," says Wickman. He believes the job can only be done by a succession of scientists working on plots protected by a succession of cooperating land managers.

Disks are cut from defoliated white fir to provide information on radial growth patterns.

Increment cores from defoliated and non-defoliated trees in old outbreak areas are measured to determine growth.

Publications available

Publications describing the results of these studies can help managers improve estimates of damage and the selection of trees for salvage logging, make better predictions of stand productivity over a rotation, and plan silvicultural treatments that reduce the vulnerability of host stands to damage.



Sharply decreased growth for 4 years after the 1936 defoliation, rapid recovery, then higher than normal growth shows on increment cores.

Plans for salvage logging should be based on estimates of which trees will recover from defoliation and which will die within 3 years. A publication which will help foresters and forest entomologists standardize estimates of defoliation is *"How to Estimate Defoliation and Predict Tree Damage,"* Agricultural Handbook No. 550, by Boyd E. Wickman. Additional details of the studies that formed the basis for this handbook are provided in *"Radial Growth in Grand Fir and Douglas-fir Related to Defoliation by the Douglas-fir Tussock Moth in the Blue Mountains Outbreak,"* Research Paper PNW-269, by B. E. Wickman, D. L. Henshaw and S. K. Gollob, and *"Tree Mortality and Top-kill Related to Defoliation by the Douglas-fir Tussock Moth in the Blue Mountains Outbreak,"* Research Paper PNW-233, by Boyd E. Wickman.

The studies of the older California outbreaks are reported in two papers by Wickman: *"A Case Study of a Douglas-fir Tussock Moth Oubreak,"* Research Paper PNW 244, and *"Increased Growth of White Fir After a Douglas-fir Tussock Moth Outbreak,"* which appeared in the January 1980 issue of the Journal of Forestry.

Copies of these publications are available from the Pacific Northwest Station.

Reducing deer/vehicle accidents

by Rick Fletcher
Rocky Mountain Station

This deer was one of many lost to traffic prior to the installation of the fence system. Scientists had collared the animal earlier for studying migration routes.

Interstate 80 is a popular highway for east-west travelers. In southern Wyoming, however, it passes through the winter range of approximately 2000 mule deer, and bisects their migration routes from the Medicine Bow Range to their winter home in the lower sagebrush lands.

Since the highway opened in 1970, over 1,000 deer have been recorded killed along a 55-mile stretch west of Laramie, (this number does not reflect the deer that were injured but able to move away from the highway before dying).

As the number of deer/vehicle accidents increased, the Wyoming Highway and Game and Fish Departments became quite concerned. In 1974, with guidance and funding from the Federal Highway Administration, they teamed up with scientists at the Rocky Mountain Station's Forest, Range, and Watershed Laboratory at Laramie to try to solve this problem. A solution was needed that kept the animals off the highway while allowing them access to their summer and winter ranges. There were several underpasses along I-80 constructed specifically for animal use, but the deer persisted in jumping the livestock fences and crossing over the highway.

Getting started

The first step was to determine how many deer were migrating across the highway, and where they were crossing. Track counts made during snow-cover periods showed that over 80 percent of the 1,200 deer that did cross, chose a single 8-mile stretch.

As a result of these and other studies, it was decided to build an 8-foot high deer fence along both sides of the Interstate within that 8-mile area. The purpose of the $240,000 fence was to funnel the deer into and through the under-passes. Though deer-proof fences had already been used successfully in Colorado and Utah, this was the first attempt on such a large scale.

Here, deer hesitate at the sight of the underpass and highway traffic. They later moved through without incident.

First encounters

The first deer to reach the new fences in the fall of 1977 were, to say the least, apprehensive. Camera and telemetry equipment recorded deer pacing up and down the fence, passing within several feet of the underpasses, but refusing to go through. Though most eventually did, they took from two weeks to three months to decide. About 200 did not cross at all that year.

In mid-February of 1977, a baiting program was initiated to help lure the unwilling deer through the underpasses. Alfalfa hay, apple pulp, and vegetable cuttings proved too tempting and most of the stragglers were persuaded to cross under the highway. In fact, some even bedded down inside the underpasses. Baiting was necessary only this first year.

Lorin Ward, leader for the Rocky Mountain Station's Land Use Impacts on Big Game unit at the Laramie lab, says, "Using the underpasses is a learning process for the deer. After they've gone through once, each successive time is usually easier."

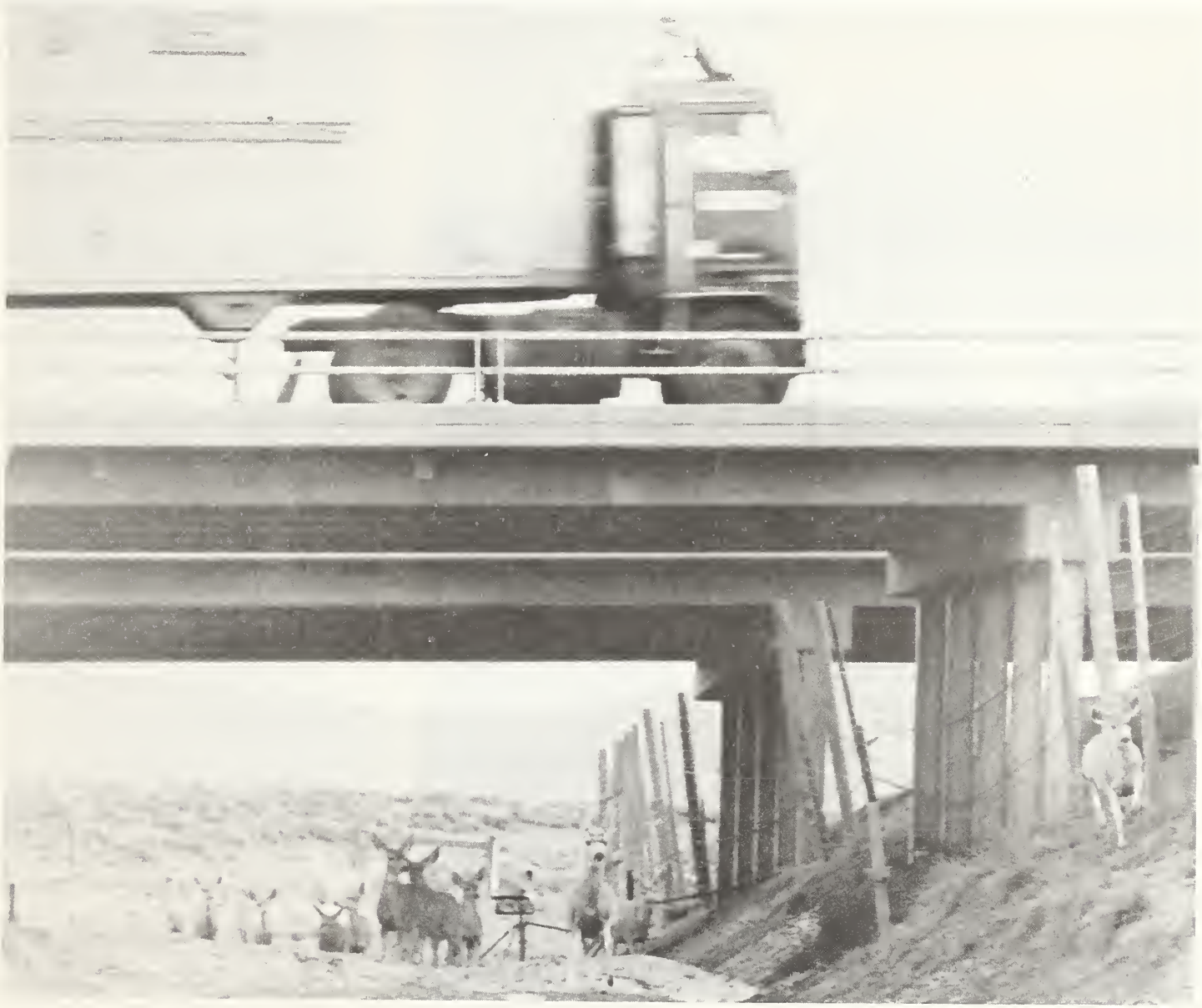
There are no problems with deer using the passes at night or while traffic is moving. The biggest problem is associated with motorists stopping to watch or photograph the animals. When this happens, the deer are usually frightened away.

Ward says that an important point in success is keeping a close watch on the fencing for holes. "Although we had several people out inspecting the fence, one small hole went unnoticed, and before it was found, at least 31 deer slipped through onto the right-of-way," he said. Twice holes were found that had been deliberately cut to gain access, and several times tires came off semi-trailer trucks and damaged the fence.

Since the fencing has been installed, accidents have been reduced dramatically - from an average of 60 per year to near zero. Both the Wyoming Highway and Game and Fish Departments, along with the Forest Service, hail it a "tremendous success." With results like this, who could disagree.

If you would like additional information on research described here, contact A. Lorin Ward, Forest, Range, and Watershed Laboratory, 222 South Second Street, Laramie, Wyoming, 82070. Phone (307) 742-6621, FTS operator 328-1110.

Though a bit skittish at first, the older does went through, followed by the rest of the herd.



Stopping seed and cone insects

by Marcia Wood
Pacific Southwest Station

Foresters in northern California injected about 100 Douglas-fir trees with insecticide earlier this year. Their purpose was to evaluate the use of injections to control insects that destroy the seeds and cones of large Douglas-fir. In this work, they were following recommendations developed during the past 4 years by Research Entomologist Tom Koerber of the Pacific Southwest Station.

According to Koerber, who is with the Station's Biology and Control of Forest Insects Unit in Berkeley, California, the insecticide which was used in the evaluation, Metasystox-R, is intended to kill seed and cone insects when they are still larvae—soft maggots, grubs, or caterpillars. The larvae emerge from eggs laid in developing seed cones by the adult females. As they live and feed within the cones, the larvae destroy part of the seed crop. At maturity, they transform into a pupal or resting stage and pass the winter either in the cones or on the forest floor. They later emerge as adults, and produce another generation.

Research Entomologist Tom Koerber of the Pacific Southwest Station has developed guidelines for protecting Douglas-fir seeds and cones from insect damage.

Target pests of the evaluation are the Douglas-fir cone midge (*Contarinia oregonensis*) and the Douglas-fir cone moth (*Barbara colfaxiana*). The adults of both these insects lay their eggs in cones in early spring, when the cones open to receive pollen. "In the case of the cone midge, the eggs are deposited between the cone scales," Koerber says. "The larvae emerge from the eggs and tunnel into the cone scales. This irritates the tree and causes it to form galls. The galls can displace the seeds and prevent them from developing, or can cause the seeds to stick to the scales, making it difficult—and uneconomical—to extract the seeds. The cone moth caterpillars feed on scales, bracts, and seeds, staying mostly near the center of the cone."

Koerber says that Metasystox-R may also retard attacks by another important insect—the Douglas-fir seed chalcid (*Megastigmus spermotrophus*). "The female chalcid deposits her eggs directly into the seeds, usually placing only one egg to a seed. The small white larvae eat the seed embryo and endosperm," Koerber explains. Of the three insects, Koerber rates the cone midge as the most damaging.

The injection technique

The injection technique is a patented process that is much like using a hypodermic needle. The insecticide is injected by driving a thin, nail-like aluminum tube into the stem of the tree, about 3 or 4 feet above the base. A small container, carrying a premeasured amount of the chemical in a "carrier" fluid, is attached to the other end of the needle. When the top and bottom portions of the container are squeezed together, the insecticide is forced through the tube into the tree. From there, it moves through the tree's sap system to all the growing points—including the cones—over a period of from 2 to 6 days. After that, the containers and tubes are discarded.

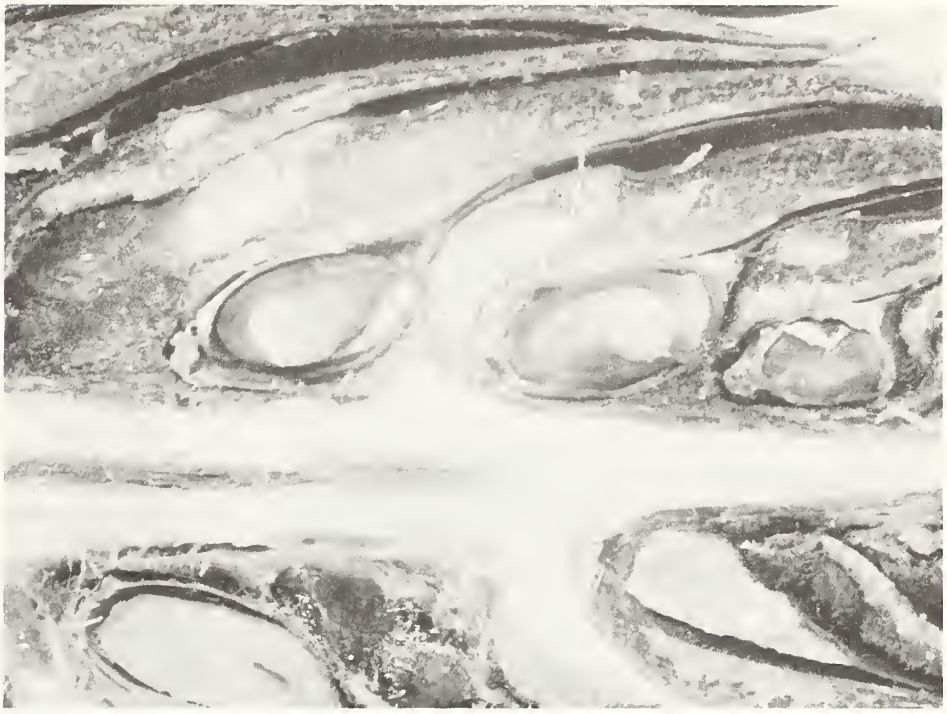
According to Koerber, the results of his earlier work with this method are "promising"—injected trees showed a 47 to 117 percent increase in uninfested seed yield per cone over the untreated trees. He expects the results of this year's work to be applicable to coastal Douglas-fir throughout its natural range.

Koerber explains that the amount of insecticide needed to protect each tree depends upon the tree's diameter. In the current evaluation of the technique, one container with 1½ grams of Metasystox-R is being used per 6 inches of tree circumference. This dosage was shown in Koerber's previous work to be the minimum amount that can be applied and still be effective. More information on his earlier study is in the article, "Bole Injected Systemic Insecticides for Control of Douglas-fir Cone Insects," which appeared in the "Proceedings of the Symposium on Systemic Chemical Treatments in Tree Culture." Copies of this reprint are available from the Pacific Southwest Station.

Superior trees used

Although both the injection system and the insecticide are registered for use on several Douglas-fir seed pests, previous tests of the system's effectiveness have been done only on small Douglas-fir, 9 to 15 inches in diameter at breast height. To determine if the procedure is effective with larger Douglas-fir, especially mature trees that have been selected as sources of superior seed, the current study is focusing on trees 23 inches in diameter, or larger.

Timber companies and several units of the National Forests of California (Pacific Southwest Region) are conducting this evaluation. The work began with the spring injections; it will conclude this fall with a thorough analysis of ripened cones from both treated trees and nearby untreated trees. The untreated trees have been carefully selected to match the treated trees in size and location.



Larvae of the Douglas-fir seed chalcid eat the seed interior and spend the winter in the hollowed-out seed coat. (Photo courtesy Weyerhaeuser Company)

Caterpillars of the Douglas-fir cone moth feed on scales, bracts, and seeds of Douglas-fir cones. (photo courtesy Weyerhaeuser Company)

Small containers, each holding a carefully calibrated amount of insecticide, are inserted 3 to 4 feet above the base of each tree.

The Pacific Southwest Region's North Zone Tree Improvement Group in Yreka, California, and the Region's Forest Insect and Disease Management Staff in San Francisco are coordinating the National Forest work, which is taking place on the Klamath National Forest. The Region's long-term goal is to have a sufficient supply of Douglas-fir seed to meet its planting needs. According to Mitch Knight of the Region's Timber Management Staff in San Francisco, the California National Forests will need more than 700 pounds of viable Douglas-fir seed each year by the late 1980's. The seed is needed primarily for raising nursery stock that can be planted on understocked, commercial Douglas-fir sites.

Currently, the Region has to deal with seed losses of anywhere from 26 to 98 percent of the total crop. This problem is compounded by the fact that Douglas-fir is a notoriously poor seed producer. It is not unusual for 2 years of good seed crops to be followed by 9 years of poor crops.

Immediate application

The Region has several immediate and future applications of the technique in mind. An immediate use would be to provide protection for the seed crop produced by selected, outstanding Douglas-fir trees. This is why the National Forests are using outstanding parent trees in natural stands for the current evaluation. The seed is needed not only for sowing at the Region's Humboldt and Placerville production nurseries, but also for progeny tests. In the progeny tests, the offspring of the superior parents will be evaluated, to determine if the desirable characteristics of the parent trees are inherited. The best-performing parents will continue to be used as seed sources; cuttings from these trees may be grafted to rootstock in seed orchards. These orchards would be cultivated exclusively for the production of high quantities of genetically superior Douglas-fir seed. By using superior—as opposed to wild—seed, the Region hopes to produce vigorous, fast-growing trees that are more resistant to pests and environmental stresses than their wild counterparts, and produce a higher quality and quantity of wood in a shorter period of time.

In the future, the Region may use the technique on seed orchard trees. Jay Kitzmiller, Regional Geneticist with the Tree Improvement Center in Chico, California, says the Region is "hoping to reach the point where the injection technique is a standard seed orchard practice."

In addition to the National Forests of California, others conducting evaluations of the injection technique this year are the Oregon State Office of the Bureau of Land Management, U.S. Department of the Interior; Georgia-Pacific Corporation; Masonite Corporation; and Louisiana-Pacific Corporation. Mark Edwards, regeneration forester with Masonite Corporation, says that in the company's previous work with Koerber, the germination rate of seed from injected Douglas-fir was twice that of untreated trees. Like the Forest Service, Masonite has a continuing demand for Douglas-fir seed. In Masonite's case, the corporation needs about 100 pounds of seed a year, for producing more than a million seedlings at its Calpella, California, container nursery. In the past, seed shortages have forced the company to buy seed from non-local, less-preferred seed source zones. As Edwards explains it, "Even though we collect as many cones as we can for as long as we can, we never have enough seed." Michele Farmer, silviculturist with Georgia-Pacific at Fort Bragg, California, echoes the complaint. "We're always short of Douglas-fir seed—we never have more than a few year's supply."

Results of this year's work will be known when the near-ripe cones of the injected trees are collected this fall. A small sample of the cones will be cut open and inspected for insect damage. Some of the seeds will be x-rayed, to determine if they are infested by seed chalcid. And, some seeds will be planted to see if the treatment caused any defects in the young trees. The size of the seed crop produced by treated trees will be compared to the crop from an equal number of the matched, untreated trees.

Advantages cited

Koerber says that the injection technique has many advantages over other approaches. Perhaps the strongest argument is that the system is self-contained. "The chemical insecticide goes directly into the tree," he says, "so there is less chance of environmental contamination than there might be with other approaches, such as spraying." Further, the equipment is portable, and is ideal for protecting trees that are located at widely separated locations, or are not within reach of equipment that has to be hauled along roads. "If you were trying to treat these trees with material sprayed from a hydraulic sprayer, it would be difficult, if not impossible, to move the equipment to any trees except those close to the road," Koerber says. "Height, too, would be a problem with a ground sprayer. Most of the cones in a large Douglas-fir would be above reach of a conventional sprayer. With the injection system, you can get all the equipment you need for one day's work—injection needles, pre-filled containers of insecticide, and a small tool for driving the needle into place—into a knapsack. Tree height is not a problem, because we believe the injected insecticide can move up the stems of trees of any height."

Koerber also claims that, "Weather conditions that would halt a spraying operation, such as snow or rain, pose no obstacle to the injection approach. You can be up to your knees in snow, and it shouldn't affect the treatment." The process is comparatively safe for the person applying the insecticide, and is simple to use. "It takes most workers about 15 minutes to learn how to make a proper injection," he says.

Problems to solve

There are, however, some problems that Koerber is currently trying to resolve. One is the wounds that result from the injections—sapwood cells in the vicinity of the puncture are killed by the treatment. Koerber believes that it is not the insecticide that is causing the damage, but instead is the carrier fluid, methyl isobutyl ketone. He is working with the manufacturer of the injection equipment to determine if a less-toxic carrier can be found. The problem must be resolved before the technique can be recommended for wide-scale use. A cooperator who is reluctant to use the injection approach in seed orchards until this phytotoxicity problem is solved explains, "We've got so much money tied up in our seed orchards that we wouldn't want to use any treatment that might possibly damage our seed trees."

Another problem is that the insecticide may interfere with seed viability. Koerber's approach has been to prescribe the lowest possible dosage of Metasystox-R. His earlier results had shown that high dosages may lead to reduced viability.

Early results indicate that the injection technique may increase the amount of uninfested seed that can be harvested from Douglas-fir cones.

Despite these problems, those involved in the current evaluation of the injection technique are enthusiastic about its potential. Mark Edwards of Masonite says, "We have been using the system for the past three years, and will continue to use it for both collection of local seed and for seed orchard work. The better the system gets, the easier it will be for us to use."

Honing fire to a precision tool

by Delpha Noble
Intermountain Station

Researchers inventory fuel remaining after a prescribed fire.

"In the future, some forest fires which start on National Forest System lands will be used for predetermined beneficial purposes rather than being put out immediately."

This policy, announced in 1978 by Assistant Secretary of Agriculture M. Rupert Cutler, is a result of land management planning stressed in the National Forest Management Act of 1976. In the Act, "Each National Forest unit is directed to use a systematic, interdisciplinary approach to achieve integrated consideration of physical, biological, economic, and other sciences."

Fire management activities are now determined by objectives set forth in Forest Service land management plans. Fire management is treated as a cost-effective way to accomplish resource management objectives. These objectives include improving timber stands and wildlife habitat, and reducing the threat of large fires by preventing accumulation of dry forest debris.

The decision to revise the traditional approach to fire was not made in haste. Forest Service studies had shown that a broader, more flexible approach to fire management would reap benefits for the ecosystems.

Research that began more than a decade ago on the Flathead and Lolo National Forests of Montana contributed to the new fire policy. The Miller Creek-Newman Ridge Study—the first known attempt to combine several disciplines in a major study—evaluated the effects of many prescribed fires. Results show that fire can be used as a precision management tool.

Fire, a natural part of the forest environment, has long been one of the driving forces in the northern Rocky Mountains. In this coniferous ecosystem, forest types such as western larch/Douglas-fir depend on fire for regeneration. Fire kills some or all of the standing crop, opens up the forest, and creates a mineral soil seedbed, allowing tree regeneration. The vegetation-soil complex has developed over thousands of years, with wildfires periodically disturbing, and stimulating, the ecosystem.

Mimicking nature

To the extent possible, man has mimicked the role of wildfire in his management of western larch/Douglas-fir stands. After harvesting the wood—usually by clearcutting—he has used fire to prepare mineral soil seedbeds and reduce the wildfire hazard created by logging residues.

In the past, after the forest became thoroughly wetted in the fall, logging debris was dozer-piled and burned—then the most common use of prescribed fire in the Northern Region. As new techniques were developed, land managers concerned with values such as energy costs and watershed protection turned to broadcast burning this debris.

About 300,000 acres of forest are harvested annually in the Northern Rocky Mountain region of the United States. Most of these acres require post-harvest treatment to assure adequate natural regeneration or to prepare the site for planting. Of several techniques available to land managers, prescribed fire is the most economical.

As a tool for preparing sites for future crops, prescribed fires have not always accomplished the needed objectives. Results in many areas have been erratic—e.g., not enough seedlings in spruce forest types, too many in larch and lodgepole pine stands. Studies showed large, unexplained variation in slash disposal and burning costs. The practice of clearcutting coupled with short fall burning periods also caused an increasing backlog of acres requiring postlogging treatment. Perhaps the most important reason for failures is the variable nature of fire itself—it can burn over any given area in an infinite number of ways.

Pioneer effort

In 1966, these concerns prompted land managers of the Northern Region and researchers of the Intermountain Station to begin a study of prescribed fire and its use in forest management. The investigative team had a specific goal—to develop criteria by which prescribed fires in logging slash could be scheduled to best meet site preparation, hazard reduction, and other management goals.

Highest priority was assigned to the western larch/Douglas-fir type growing on sites where subalpine fir is climax in the Northern Rocky Mountain region. In the autumn of 1966, sixty 10-acre units were laid out on the Miller Creek block of the Flathead National Forest. In 1968, 16 units ranging in size from 21 to 58 acres were established on the Newman Ridge block of the Lolo Forest.

Into the field

Research crews began working in earnest during the summer of 1967 on the Miller Creek block. Much of the logging had been completed—up to 100 tons of slash lay on each acre on many of the units. The crews inventoried the slash and measured depth of the duff layer and the water contents of the duff and fuel. When atmospheric conditions were suitable, a unit was burned. Time of burning depended on weather and fuel characteristics. During mid-summer, the burning was often done at night; when fire danger was less, it was done during the day.

Heights of the smoke columns were measured. Researchers aboard an aircraft tracked smoke plumes and used special instruments to measure the concentration of particulate matter and gases. Five ground stations in the vicinity continuously monitored air quality.

Fire intensity was measured with water-can analogs—the amount of water evaporated from these cans is proportional to the amount of heat received. Researchers measured fire effectiveness by inserting spikes through the duff and into the mineral soil beneath. The length of spike exposed after the fire was equal to the depth of duff burned. Fuel remaining after each fire also was inventoried.

Researcher checks air quality data recorded by a ground station.

Through the ensuing years researchers documented plant succession. They also measured seedbed conditions, monitored seed dispersal onto the clearcut units, and inventoried seedling survival and growth. Small mammals on the burned plots and in adjacent undisturbed timber were trapped and counted. Watershed and soil scientists established batteries of runoff plots and monitored the amount and nutrient content of overland flow and sediment moving from the plots. They also determined the physical and chemical characteristics of the soil that were affected by the treatments.

A total of 73 sample plots in 55 different units were burned, and the data from them was used in subsequent analyses. The treatment record represents a realistic range of prescribed burning opportunities in the Northern Rocky Mountains.

Application

As each study in each discipline—fire, air quality, silviculture, vegetation, wildlife, and soils and watershed—was completed, the scientists published the information for immediate application. Approximately 30 publications have resulted from the research conducted at Miller Creek and Newman Ridge.

Now the Intermountain Station has published an integrated summary of that research. The summary draws upon the continuing deposits in the savings account of knowledge, and provides management guidelines for use of prescribed fire in the western larch/Douglas-fir forests of western Montana. The summary appears in *"Clearcutting and Fire in the Larch-fir Forests of Western Montana—A Summary of Effects on Several Resources,"* General Technical Report INT.FR23. Norbert V. DeByle, one of the Station scientists who participated in the study, is the major author.

Fire-weather station, Newman Ridge.

The results discussed in the summary report are directly applicable to clearcut sites in western Montana and surrounding States and Provinces with similar geology, soils, forest types, and habitat types, if similar loads of logging residue are broadcast-burned. The report contains detailed site, stand, habitat, and treatment descriptions, thus informed judgment can be used in applying the information elsewhere.

DeByle says general relationships should apply widely, even though the specific quantities cited might be unique to the study area. The results from some disciplines, such as air quality management, will apply more broadly than will the results from others, such as silviculture.

It is up to the land manager to decide if the results from this work apply partially or wholly to the set of conditions with which he is working. After reading the descriptions from Miller and Newman and mentally comparing them to the concerned site and treatment, DeByle suggests the manager should ask: Are the results applicable here? What results may apply? To what extent? Can I extrapolate the numbers to my situation, or do only the general relationships apply?

The "Results" section of the summary report, presented in six chapters written by the principal investigator(s), includes:

Fire Behavior and Effects, by Rodney A. Norum, Pacific Northwest Station, Institute of Northern Forestry, Fairbanks, Alaska
In this chapter, Norum discusses fuel and duff consumption and ignition patterns. He includes a procedure to estimate the percent of an area that will be burned bare to mineral soil.

Air Quality and Smoke Management, by D. F. Adams, E. Robinson, P. C. Malte, R. K. Koppe (all of Washington State University, Pullman), and N. V. DeByle
This section contains a wealth of information that has broad application. The team reports on smoke composition, ground level particulates, and aircraft monitoring of smoke and emissions.

Silviculture, by Raymond C. Shearer, Intermountain Station, Forestry Sciences Laboratory, Missoula, Montana
Shearer describes the conditions following prescribed fires in clearcuts at Miller and Newman; he also relates these conditions to conifer regeneration. The results are contrasted with nearby uncut areas burned by wildfire, or slashed but unburned clearcuts. He also discusses germination, seedbed condition, seed production and dispersal, seedling survival, and natural regeneration.

Vegetative Recovery and Development, by Peter F. Stickney, Intermountain Station, Forestry Sciences Laboratory, Missoula, Montana
Stickney reports that during the first 6 to 9 years after prescribed burning, development of vegetation on the units at Miller and Newman followed a characteristic pattern. The author discusses herb and shrub successional stages, effect of fire, response to burning, and composition of life form components. Photographs showing vegetative development are included in this section.

Small Mammal Populations, by Curtis H. Halvorson, Fish and Wildlife Service, Denver Wildlife Research Center, Fort Collins, Colorado
Species composition and relative abundance of small mammals on selected units at Miller and Newman were determined and related to patterns of plant succession. Halvorson reports on the small mammal populations in old-growth timber, and population changes after clearcutting and broadcast burning.

Soils and Watershed, by Norbert V. DeByle and Paul E. Packer, Intermountain Station, Forestry Sciences Laboratory, Logan, Utah
DeByle and Packer discuss the effects of clearcutting and burning on soil properties, quantity and quality of overland flow, and amount and nutrient content of eroded material.

The following publications related to the Miller Creek-Newman Ridge studies, in addition to the summary report, are available from the Intermountain Station:

Beaufait, William R., Charles E. Hardy, and William C. Fischer. 1977. *Broadcast Burning in Larch-fir Clearcuts: The Miller Creek-Newman Ridge Study.* USDA For. Serv. Res. Pap. INT-175, rev., 53 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

DeByle, Norbert V., and Paul E. Packer. 1972. *Plant Nutrient and Soil Losses in Overland Flow from Burned Forest Clearcuts. In* Watersheds in Transition, p. 296-307. AWRA Symp. Proc.

Norum, Rodney A. 1974. *Smoke Column Height Related to Fire Intensity.* USDA For. Serv. Res. Pap. INT-157, 7 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Shearer, Raymond C. 1975. *Seedbed Characteristics in Western Larch Forests after Prescribed Burning.* USDA For. Serv. Res. Pap. INT-167, 26 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

The short-tailed weasel (Mustela erminea) is a common predator of small mammals that inhabit uncut timber stands and broadcast-burned cutovers. (photo courtesy U.S. Fish and Wildlife Service)

New publications

Managing spruce-fir

Engelmann spruce - subalpine-fir forests are the largest and most productive timber resource in the central Rockies. Managers of these lands need to feel confident that they have sound, up-to-date procedures on which to base their decisions.

To help provide this information, scientists at the Rocky Mountain Station recently estimated the potential timber production of these forests under intensive management. Estimates on previously developed field and computer simulation procedures are presented for various combinations of stand density, site quality, ages, and thinning schedules.

These studies are reported in a new publication, "*Management of Spruce-fir in Even-Aged Stands in the Central Rocky Mountains,*" by Robert R. Alexander and Carleton B. Edminster.

The authors cover such areas as establishment of regeneration; precommercial thinning; diameter, height, basal area, cubic volume, and board foot volume growth; maximizing board-foot volume yields with clearcut and shelterwood options; and tradeoffs to increase values of other non-timber resources.

Land managers will find this publication of value in projecting future development of spruce-fir forests managed not only for timber, but other resources as well. For your copy, write the Rocky Mountain Station and request Research Paper RM-217-FR23.

The Recreation Opportunity Spectrum

Diversity of opportunity is the key to providing for people's varied tastes and preferences in recreational experiences, according to researchers at the Pacific Northwest and Intermountain Stations. Building programs around the mythical "average person" can greatly miss the mark, they explain.

The basic concept of "Recreation Opportunity Spectrum," which had been proposed previously by other researchers, has been developed as a framework to help forest managers accommodate a variety of recreation needs. The framework should help answer questions about the role of public agencies and private firms in responding to increased demand for outdoor recreation opportunities. The spectrum refers to the degree of change from a natural forest environment. The spectrum ranges from unchanged primitive settings, reached by people on foot, to "modern", highly developed compounds with electric hook-ups and hot showers, reached by paved roads.

The authors begin their report with a story about the changes which have taken place over 75 years at a lake in the Washington Cascades. It illustrates how increased human use and physical changes—such as roads and campground facilities—gradually change the types of recreation experience available to people who visit an area.

Managers can manipulate six factors which affect recreation settings: access, nearby other non-recreational resource uses (such as logging or mining), on-site management, social interaction, acceptability of visitor impacts, and the acceptable level of regimentation. Each of these can range from primitive to "modern", from a little to a lot, and from acceptable to unacceptable, depending on people's expectations. The framework recognizes that quality recreation occurs along the entire spectrum and is achieved where a given setting satisfies the desires of a particular individual.

New research on the relationship between settings, activities, and experiences, and ways people's tastes are shaped by their recreation experiences and available opportunities, are expected to develop further the concept and application of the recreation opportunity spectrum.

The concept is described in "*The Recreation Opportunity Spectrum: A Framework for Planning, Management, and Research,*" General Technical Report PNW-98, by Roger N. Clark and George H. Stankey. Copies are available from the Pacific Northwest Station.

Measuring residue with photos

Dealing with downed woody residues in Sierra mixed Conifer and Sierra true fir types will be easier for forest managers who use a new publication from the Pacific Northwest Station that combines color photos and detailed descriptions of the residue pictured.

The photographs illustrate a range of residue loading levels that result from various harvest methods and slash treatments. The detailed information that accompanies each photo describes the weight and volume per acre of six diameter classes of residue. Harvest information includes the cruise of the stand as well as amount of timber removed. There is also an assessment of the fire behavior of the material pictured and the resistance of the fuel to fire control.

Comparing photos with residue on the ground makes it easier to estimate the amount and characteristics of residue. Accompanying harvest information can be used to predict the amount of residue that will result from a planned harvest. The photos and descriptions also provide a means of communication among specialists and managers about the amount and kind of residue that should remain in the forest to provide adequate nutrient cycling, protect the soil from erosion, and provide habitat for wildlife.

Material for the publication was developed with the cooperation of the Forest Service's Pacific Southwest Region and Pacific Southwest Station, and the Department of Forestry, State of California. Copies of *"Photo Series for Quantifying Forest Residues in the Sierra Mixed Conifer Type and Sierra True Fir Type,"* General Technical Report PNW-95, by Wayne G. Maxwell and Franklin R. Ward are available from the Pacific Northwest Station.

Two similar reports by the same authors were published in 1976. They are *"Photo Series for Quantifying Forest Residues in the Coastal Douglas-fir-hemlock Type and Coastal Douglas-fir-hardwood Type,"* General Technical Report PNW-51, and *"Photo Series for Quantifying Forest Residues in the Ponderosa Pine and Associated Species Type, Lodgepole Pine Type,"* General Technical Report PNW-52. PNW-51 is out of print but may be available through library services; PNW-52 is available from the U.S. Government Bookstore in Seattle, 915 2nd Ave., Rm. 194, Seattle, Washington, 98174.

Classification system developed

One of the main obstacles facing resource managers today is the absence of a universal classification system for these resources. This absence limits overall land use classification, resource planning, inventory and assessment, interpretation of environmental uses and impacts, and other activities concerned with natural resource management.

Scientists at the Arizona Game and Fish Department, University of Arizona, and Rocky Mountain Station have developed a new classification framework for ecosystems that is described in a new report titled *"A Digitized Systematic Classification for Ecosystems with an Illustrated Summary of the Natural Vegetation of North America,"* by David E. Brown, Charles H. Lowe, and Charles P. Pase.

The system, originally developed for southwestern North America, has now been expanded to include all of North America, and can be adapted to include all the ecosystems of the world.

The main advantage of this system over others is that it is a digitized multiple-level and open-ended arrangement of hierarchial components that provides for unlimited information content.

The paper discusses the seven hierarchial levels the system uses, contains digitizes tables of the natural vegetation of the world that apply to the classification system, and has photographic examples of the different classes of world vegetation.

For your copy of this report, write the Rocky Mountain Station and request General Technical Report RM-73-FR23.

Measuring chaparral moisture content

The way that dense, shrubby plants in chaparral ecosystems respond to fire is strongly influenced by the amount of moisture in each plant. A carefully designed procedure for making the best possible estimates of moisture content in manzanita, chamise, and other chaparral species, is described in a new publication from the Pacific Southwest Station. The 28-page guide, *"Measuring Moisture Content in Living Chaparral: A Field User's Manual,"* was prepared by Clive M. Countryman, formerly of the Pacific Southwest Station, and William A. Dean, Assistant Manager of the Chaparral Management Research and Development Program.

Countryman and Dean explain that moisture content of live fuel can be used, in conjunction with other estimates of fire behavior, to evaluate fire hazard and to predict fire behavior in fire prevention, wildfire suppression, and prescribed fire activities. The authors describe factors affecting moisture content, outline the requirements for establishing key locations for sampling fuels, explain when and how many samples to collect, and show how to compute moisture content.

Countryman and Dean recommend that fuel samples be dried in either a mechanical convection or gravity convection oven. They explain that their preference for this method over other systems stems from the fact that the oven drying technique is relatively safe, reliable, and simple to use, and that equipment for this procedure is readily available.

In collecting fuel samples, only live twigs and foliage should be saved – flowers, seed pods, nuts, berries, and similar material should be removed.

The procedures described in the guide are now being used by the California Department of Forestry and the National Forests of California (Pacific Southwest Region) in measuring fuel moisture at 15 specially selected collection sites throughout California. According to Countryman and Dean, the system is equally applicable to chaparral-covered areas of other Western States.

Copies of the publication, issued as General Technical Report PSW-36, are available from the Pacific Southwest Station.

Equations for fire containment

Prefire planning and initial attack require solution of the classic fire problem, "How much containment capability is needed?" Additional considerations often modify or even override the answer to the strictly-limited question, but it is still necessary to estimate potential fire sizes and fire suppression requirements.

Concern over rising costs of wildland fire suppression has stimulated more intensive planning for fire control. For example, the computer program FOCUS was designed to test fire control plans and dispositions of personnel and equipment to increase efficiency and reduce costs.

For preliminary planning, and as a ready aid for dispatcher use, a simplified, mechanized process is now available for solving the fire containment problem. Researchers at the Intermountain Station's Northern Forest Fire Laboratory have developed simple equations that can be used on a programmable pocket calculator for this purpose. These equations closely approximate the calculations performed by part of the FOCUS program.

The equations and operating procedures are included in *"Fire Containment Equations for Pocket Calculators,"* Research Note INT-268, FR 23, by Frank A. Albini, mechanical engineer, and Carolyn H. Chase, mathematician. Write to the Intermountain Station for a copy of the report.

Out of the kitchen - into the woods!

Fire managers, take note. If your home kitchen is equipped with a microwave oven, you might want to use it in the field. With a microwave oven, a portable generator, and reasonably accurate scale, the moisture content of dead, woody fuels in a proposed fire area can be determined at a site in less than a half hour.

A recent Research Note, *"Determining the Moisture Content of Some Dead Forest Fuels Using a Microwave Oven,"* Research Note INT-277-FR 23, describes tests that were conducted on fresh duff and dead branchwood from forests near Missoula, Montana. The note, published by the Intermountain Station, includes procedures and examples of field use. Authors are Rodney A. Norum, research forester, Pacific Northwest Station, Institute of Northern Forestry, Fairbanks, Alaska; and William C. Fischer, research forester, Intermountain Station, Northern Forest Fire Laboratory, Missoula.

Combined with carefully written prescriptions, the method provides the land manager with the means to make better decisions leading to improved fire treatments. The same technique, using fire behavior models, will lead to better predictions of the behavior of wildfires and offer sound information for suppression strategies.

Copies of the note are available from the Intermountain Station.

Managing for huckleberries

Huckleberries will continue to be the traditional excuse for fall outings in the mountains of Oregon and Washington, but the berries are getting harder to find. Some of the most popular fields of big huckleberry *(Vaccinium membranaceum)* are shrinking because periodic wildfires no longer discourage the invasion of conifers. In good years many areas still produce more than 50 gallons an acre. At $10 a gallon—the average 1977 price—the berries are more valuable than the invading conifers.

Forest managers who want to enhance berry production can get advice from a new report from the Pacific Northwest Station. From 1972 through 1977, Plant Ecologist Don Minore and his associates studied a number of ways to reduce competition to the huckleberry: sheep grazing, burning, cutting and burning, application of chemicals, introduction of root rot, and combinations of these.

Although all treatments were expensive and some delayed berry production as long as 5 years, several were promising. The most effective treatment was application of a solution of 2,4-D and water to the cut bark of competing trees. This effectively killed the conifers without disturbing the huckleberry bushes and doubled berry production 3 years after treatment. Where herbicide use is undesirable, Minore says, tree girdling would produce the same result, at higher cost. Both treatments would be less expensive if applied before a dense overstory develops.

Bulldozing trees and burning them after they have dried for a year should be considered if the overstory is dense and delays of 5 years in berry production are acceptable. Sheep grazing does not affect competition but does add nitrogen to the soil. Sheep and berry pickers are not always compatible, so if sheep are used they should be brought in before berries ripen. Eventually inoculation of trees with the root rot *Phellinus weirii* may be effective, but results of this treatment will not be available for several years. The authors recommend that huckleberry fields selected for management be chosen carefully on the basis of traditional use, access, and berry production. If intensive management is attempted in the future, the techniques for producing huckleberry shrubs easily from seed are available.

Details are included in *"Huckleberry Ecology and Management Research in the Pacific Northwest,"* General Technical Report PNW-93, by Don Minore, Alan W. Smart and Michael E. Dubrasich. Copies are available from the Pacific Northwest Station.

Fire and chaparral soils

Research on the effects of fire on soils in Southern California chaparral ecosystems is summarized in a new Research Paper from the Pacific Southwest Station. *"Soil Heating in Chaparral Fires: Effects on Soil Properties, Plant Nutrients, Erosion, and Runoff,"* Research Paper PSW-145, highlights data collected during prescribed burns and a wildfire. The authors are Research Soil Scientist Leonard DeBano, formerly of the Pacific Southwest Station and now with the Rocky Mountain Station, and two PSW Station scientists—Research Hydrologist Raymond M. Rice and Research Botanist C. Eugene Conrad. They include in their report some generalized curves that indicate the soil heating that is likely to occur during light, moderate, and intense fires. The information is intended primarily for land managers who need to be able to predict the effects that prescribed burn—or wildfires—will have on nutrient availability, as well as on soil wettability and other aspects of brushland hydrology.

A typical effect is the loss of total nitrogen during a fire. This loss is of concern because nitrogen is often in low supply in chaparral stands. The researchers found that 50 percent of the nitrogen was lost when the soil or litter was heated to 572 degrees F; 75 percent when heated to 752 degrees F; and 100 percent when heated to 932 degrees F. Additionally, some of the bacteria that convert gaseous nitrogen or nitrite nitrogen to the ammonia or nitrate forms used by plants, are very sensitive to heat, especially when soils are moist. This situation leaves the land manager with a difficult decision. To prescribe burn in the winter, running a cool fire over moist soil, would mean that the least possible amount of nitrogen would be volatilized. But, such a fire would probably do as much damage to the principal nitrifying bacteria as a hot, dry, summer burn. Details about this and other fire effects are in the report. For copies, contact the PSW Station.

State-of-the-art for remote sensing

Remote sensing is an information gathering technique that is becoming more a part of resource inventories and land use planning.

A new publication reviews the state-of-the-art of remote sensing of wildland resources. It could be termed the "everything you always wanted to know about remote sensing" book—covering such things as remote sensing systems, the state of remote sensing applications, costs, future plans and goals, plus an extensive list of literature citations.

It also details terminology, classification and mapping, measurement of resource parameters, observations and counts of occurrences, data collection and processing, satellite technology, agency programs, and continuing research and development goals.

For your copy, write the Rocky Mountain Station and request *"Remote Sensing of Wildland Resources; A State-of-the-Art Review,"* General Technical Report RM-71-FR23, by Robert C. Aldrich.

SEAM user guides

Federal lands contain a majority of the metallic minerals, as well as major resources of coal, oil shale, uranium, geothermal steam, and oil and gas. These same lands, however, also contain valuable nonmineral resources, including timber, forage, water, wildlife, and wilderness. The Government's holdings of such resources are among the most significant in the world.

The long-standing premise that mineral activity is the most valuable use of a tract of land is increasingly being challenged. The value of scarce, nonmineral surface resources has also increased. In fact, when the mineral and nonmineral values are weighed, the value of the nonmineral resources may outweigh the value of the mineral resources.

Given the situation of mineral and nonmineral values on the same tract of Federal land, decisions as to proper use involve balancing the values of these two types of resources. Achieving a balance requires adequate information about, and analysis of, all values involved.

Realizing the complexity of such decisions, in 1973 the Forest Service chartered the Surface Environment and Mining Program (SEAM). The Program was designed to coordinate research, development, and application activities related to land impacts resulting from minerals exploration in the West. SEAM became a part of the Intermountain Station in 1975.

From 1973 to 1979, SEAM sponsored more than 150 research and development projects. Together, the projects have greatly added to the body of knowledge surrounding the management of land in mineralized areas.

To get this knowledge to specialists in the field in a form they could readily use, SEAM brought together researchers and users from industry, Federal agencies, and the academic community to share their practical knowledge and research results in a series of workshops. The information presented has been organized into user guides on five subjects: vegetation, soils, hydrology, engineering, and sociology and economics. Cross-referencing among the guides is provided in the index of each.

Each guide focuses on a specific discipline involved in managing surface resources that may be affected by mineral activities, and is written for specialists in these disciplines. The guides will also be useful to land managers, planners, and other specialists since many activities related to minerals-area management demand a variety of skills to achieve an integrated approach. To clarify specific points or to stay abreast of new developments, readers are urged to contact the researchers who contributed to the guides or their regional reclamation specialists.

The guides, available from the Intermountain Station, are:
"User Guide to Vegetation," General Technical Report INT-64-FR23;
"User Guide to Soils," General Technical Report INT-68-FR23;
"User Guide to Hydrology," General Technical Report INT-74-FR23;
"User Guide to Engineering," General Technical Report INT-70-FR23;
"User Guide to Sociology and Economics," General Technical Report INT-73-FR23.

New newsletter

The USDA Forest Service and the Bureau of Land Management have teamed to publish the new "Resources Evaluation Newsletter."

Scheduled to be printed about every 2 months, the newsletter serves as a focal point to exchange ideas and procedures for evaluating our natural resources. Each issue will contain news about techniques development and use in the Forest Service, BLM, and other agencies or institutions; a current literature section; and announcements of meetings, workshops, etc.

This newsletter replaces the BLM's "Resource Inventory Notes." Subscribers to the Notes will automatically receive the Resources Evaluation Newsletter. Gyde Lund, project leader for National Resource Inventory Techniques at Ft. Collins, is the editor.

If you would like to be placed on the mailing list, free of charge, write: USDI Bureau of Land Management, Division of Resource Inventory System (D-460), Building 50, Denver Federal Center, Denver, Colorado 80225.

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